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DEER CREEK RESERVOIR, FAYETTE AND PICKAWAY COUNTIES, OHIO

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

PREPARED FOR
NATIONAL ENVIRONMENTAL RESEARCH CENTER

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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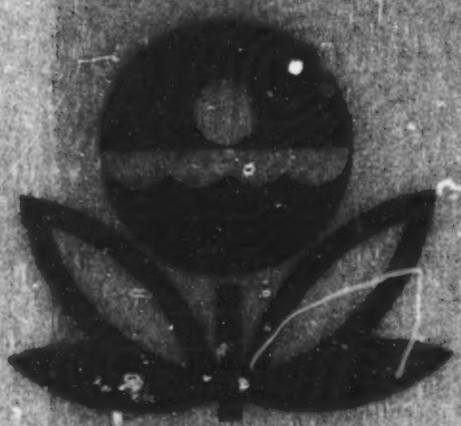

REPORT
ON
DEER CREEK RESERVOIR
FAYETTE AND PICKAWAY COUNTIES
OHIO
EPA REGION V
WORKING PAPER No. 398

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

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WITH THE COOPERATION OF THE

OHIO ENVIRONMENTAL PROTECTION AGENCY

AND THE

OHIO NATIONAL GUARD

JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

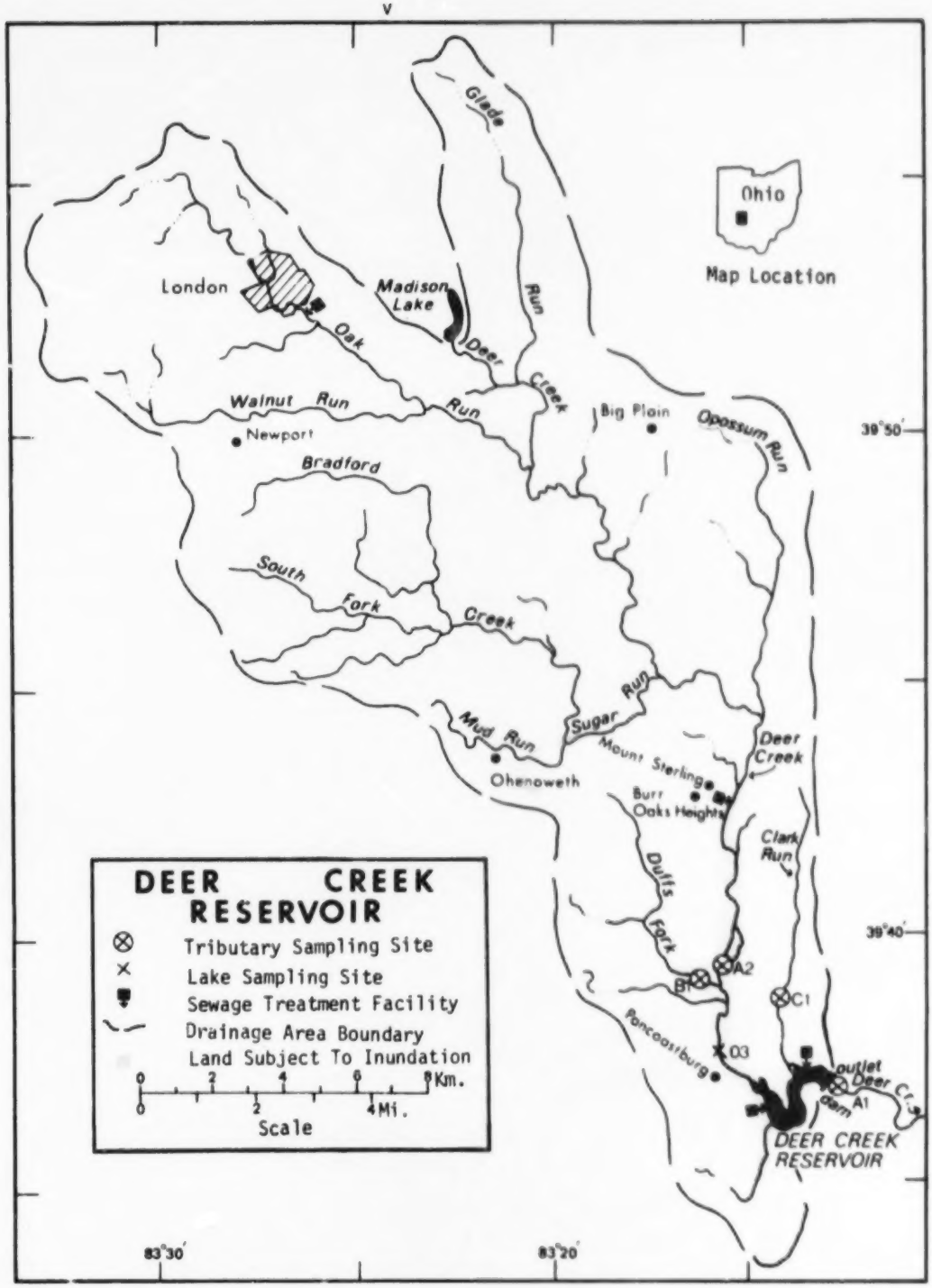
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


Glade
Run
Ohio
Map Location
London
Madison Lake
Deer Creek
Oak Run
Walnut Run
Run
Big Plain
Opossum Run
39°50'
Newport
Bradford
South Fork
Creek
Mud Run
Sugar Run
Mount Sterling
Deer Creek
Ohenoweth
Burr Oaks Heights
Clark Run
Dutts Fork
39°40'
A2
B1
C1
Roncoasburg
03
outlet Deer Cr.
Dam
A1
DEER CREEK RESERVOIR
DEER CREEK RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Land Subject To Inundation
0 2 4 6 8 Km.
0 2 4 Mi.
Scale
83°30'
83°20'

DEER CREEK RESERVOIR

STORET NO. 3906

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Deer Creek Reservoir is eutrophic. It ranked ninth in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Nine of the lakes had less median total phosphorus, 17 had less median dissolved phosphorus, 18 had less median inorganic nitrogen, seven had greater mean Secchi disc transparency, but only one had less mean chlorophyll a. Marked depression of dissolved oxygen with depth occurred at station 1 in August and October.

Field limnologists noted algal blooms at all stations during the spring sampling (April, 1973).

It is reported that suspension of colloidal clay is a problem in this reservoir (Ketelle and Uttormark, 1971).

B. Rate-Limiting Nutrient:

The algal assay results indicate the reservoir was phosphorus limited at the time the sample was collected (04/28/73). The lake data indicate phosphorus limitation at the other sampling times as well.

C. Nutrient Controllability:

1. Point sources--During the sampling year, Deer Creek Reservoir received a total phosphorus load more than four times that

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* See Appendix A.

proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). The actual loading may even be somewhat higher since conservative estimates were made of the phosphorus contributions of the two Deer Creek State Park wastewater treatment plants because of uncertainty as to populations served. Also, no assessment was made of the probable direct phosphorus contributions resulting from the heavy recreational use of the reservoir.

It is estimated that the known point sources contributed nearly 37% of the total phosphorus load during the sampling year. While even complete removal of phosphorus at the point sources would still leave a loading more than two times the eutrophic loading, it is likely that a high degree of phosphorus removal would at least reduce the incidence and severity of nuisance algal blooms, particularly in view of the rather short mean hydraulic retention time of the reservoir and the questionable applicability of Vollenweider's model.

2. Non-point sources--The non-point phosphorus contributions of the Deer Creek Reservoir tributaries amounted to about 63% of the total phosphorus load during the sampling year. However, the phosphorus export rates of the streams were relatively low (see page 11) and compare well with unimpacted Ohio streams sampled elsewhere.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 5.17 kilometers^2.
2. Mean depth: 5.0 meters.
3. Maximum depth: >10.4 meters.
4. Volume: 25.850 x 10^6 m^3.
5. Mean hydraulic retention time: 42 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Deer Creek	613.8	6.1
Duffs Fork	32.4	0.3
Clark Run	16.7	0.2
Minor tributaries & immediate drainage -	49.3	0.6
Totals	712.2	7.2

2. Outlet -

Deer Creek	717.4**	7.2

C. Precipitation***:

1. Year of sampling: 110.8 centimeters.
2. Mean annual: 98.4 centimeters.

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† Table of metric equivalents--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Deer Creek Reservoir was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. During the April and October visits, samples for physical and chemical parameters were collected from three stations on the lake and from one or more depths at each station (see map, page v). Only stations 1 and 2 were sampled in August because of low water levels. During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the sampled stations for phytoplankton identification and enumeration; and during the April visit, a single 18.9-liter depth-integrated sample was composited for algal assays. The maximum depths sampled were 10.4 meters at station 1, 4.3 meters at station 2, and 1.2 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR DEER CREEK RESERVOIR
STORET CODE 3906

	1ST SAMPLING (4/28/73) 3 SITES			2ND SAMPLING (8/ 1/73) 2 SITES			3RD SAMPLING (10/10/73) 3 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	11.1 - 13.9	13.1	13.4	24.4 - 26.9	25.8	25.9	18.8 - 22.7	20.4	20.3
DISS OXY (MG/L)	9.0 - 10.0	9.3	9.2	1.1 - 10.2	6.0	6.8	1.8 - 11.8	5.6	4.6
CNDCTVY (MCROMO)	440. - 530.	496.	500.	463. - 520.	485.	480.	426. - 488.	450.	444.
PH (STAND UNITS)	7.9 - 8.3	8.2	8.3	7.8 - 8.8	8.3	8.2	7.6 - 8.8	8.1	8.1
TOT ALK (MG/L)	164. - 204.	191.	194.	174. - 235.	193.	186.	191. - 226.	203.	199.
TOT P (MG/L)	0.094 - 0.339	0.149	0.112	0.035 - 0.103	0.055	0.046	0.047 - 0.185	0.088	0.067
ORTHO P (MG/L)	0.036 - 0.058	0.042	0.039	0.007 - 0.016	0.011	0.009	0.015 - 0.037	0.027	0.030
NO2+NO3 (MG/L)	3.600 - 4.000	3.920	4.000	2.420 - 2.960	2.717	2.760	0.780 - 1.150	0.990	1.010
AMMONIA (MG/L)	0.070 - 0.130	0.086	0.080	0.070 - 0.200	0.107	0.095	0.060 - 0.310	0.139	0.080
KJEL N (MG/L)	0.500 - 1.100	0.740	0.600	0.400 - 0.700	0.583	0.600	0.700 - 1.300	0.986	0.900
INORG N (MG/L)	3.730 - 4.080	4.006	4.070	2.510 - 3.040	2.823	2.905	0.840 - 1.460	1.129	1.090
TOTAL N (MG/L)	4.500 - 4.900	4.660	4.600	3.000 - 3.600	3.300	3.310	1.690 - 2.350	1.976	1.880
CHLRPYL A (UG/L)	11.7 - 14.4	13.4	14.2	8.0 - 9.9	8.9	8.9	3.8 - 12.4	7.0	4.7
SECCHI (METERS)	0.1 - 0.5	0.3	0.4	0.9 - 1.2	1.1	1.1	0.8 - 1.2	1.0	0.9

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/28/73	1. Flagellates	2,373
	2. Melosira sp.	744
	3. Cryptomonas sp.	538
	4. Navicula sp.	333
	5. Blue-green filaments	253
	Other genera	1,170
	Total	5,411
08/01/73	1. Flagellates	653
	2. Cyclotella sp.	522
	3. Melosira sp.	261
	4. Euglena sp.	176
	5. Nitzschia sp.	102
	Other genera	201
	Total	1,915
10/10/73	1. Flagellates	4,939
	2. Microcystis sp.	2,120
	3. Raphidiopsis sp.	1,552
	4. Merismopedia sp.	1,180
	5. Centric diatoms	1,180
	Other genera	5,484
	Total	16,455

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/28/73	01	14.4
	02	14.2
	03	11.7
08/01/73	01	9.9
	02	8.0
	03	-
10/10/73	01	4.7
	02	12.4
	03	3.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.024	3.732	5.9
0.050 P	0.074	3.732	22.3
0.050 P + 1.0 N	0.074	4.732	21.1
1.0 N	0.024	4.732	6.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Deer Creek Reservoir was high at the time the sample was collected. Also, the increased yield when orthophosphorus was added indicates that the reservoir was phosphorus limited at that time. Note that the addition of only nitrogen did not result in a significant increase in yield as compared with that of the control.

The reservoir data also indicate phosphorus limitation. At all sampling times, the mean inorganic nitrogen to orthophosphorus ratios were 42 to 1 or greater.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and April when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1 and C-1 and multiplying the means by the ZZ area in km^2.

The operator of the Mount Sterling wastewater treatment plant provided monthly effluent samples and corresponding flow data. The operators of London and Deer Creek State Park plants did not participate in the Survey, and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Mount Sterling†	1,536	act. sludge	701.9	Deer Creek
London††	6,815	act. sludge	2,579.5*	Oak Run
Deer Creek** State Park (N)	75	act. sludge	28.4*	Deer Creek Res.
Deer Creek** State Park (SE)	50	act. sludge	18.9*	Deer Creek Res.

2. Known industrial - None

† Maddux, 1973.
†† Birch, 1973.
* Estimated at 0.3785 m^3/capita/day.
** Birch, 1975.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Deer Creek	15,700	54.8
Duffs Fork	670	2.4
Clark Run	465	1.6
b. Minor tributaries & immediate drainage (non-point load) -	1,195	4.2
c. Known municipal STP's -		
Mount Sterling	2,645	9.2
London	7,730	27.0
Deer Creek State Park (combined plants)	140	0.5
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	90	0.3
Total	28,635	100.0

2. Outputs -

Lake outlet - Deer Creek 22,850

3. Net annual P accumulation - 5,785 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Deer Creek	609,805	80.7
Duffs Fork	38,325	5.1
Clark Run	18,605	2.5
b. Minor tributaries & immediate drainage (non-point load) -	56,620	7.5
c. Known municipal STP's -		
Mount Sterling	3,000	0.4
London	23,180	3.1
Deer Creek State Park (combined plants)	425	<0.1
d. Septic tanks - Unknown	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	5,580	0.7
Total	755,540	100.0

2. Outputs -

Lake outlet - Deer Creek	796,410

3. Net annual N loss - 40,870 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Deer Creek	26	993
Duffs Fork	21	1,183
Clark Run	28	1,114

* See Working Paper No. 175.

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	5.54	1.12	146.1	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Deer Creek Reservoir:

"Dangerous" (eutrophic loading)	1.28
"Permissible" (oligotrophic loading)	0.64

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, unknown and unsampled point sources discharging directly to the lake, or underestimation of the nitrogen loads from the Deer Creek Park wastewater treatment plants. Whatever the cause, a similar loss of nitrogen has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3926	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLE. SANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	342
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	242
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	390H	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SOO- MEAN SEC	MEAN CHLORA	15- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	240
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.490	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.175	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR JMIU 1/21/75

LAKE CODE 3906 JEEM CREEK RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 717.4

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3906A1	717.4	11.75	12.91	16.62	13.39	7.99	5.04	3.03	2.01	1.61	1.61	3.51	6.74	7.15
3906A2	613.8	10.11	10.93	14.05	11.33	6.80	4.36	2.61	1.76	1.44	1.44	3.06	5.80	6.11
3906B1	32.4	0.51	0.62	0.82	0.65	0.37	0.21	0.13	0.08	0.05	0.06	0.13	0.28	0.33
3906C1	10.7	0.26	0.31	0.42	0.34	0.20	0.10	0.07	0.04	0.03	0.03	0.07	0.15	0.17
3906Z2	54.4	0.88	1.05	1.33	1.08	0.62	0.37	0.23	0.14	0.10	0.10	0.24	0.51	0.55

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 717.4
SUM OF SUB-DRAINAGE AREAS = 717.3

TOTAL FLOW IN = 86.25
TOTAL FLOW OUT = 86.22

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3906A1	5	73	5.47	5	6.99				
	6	73	19.00	9	9.51				
	7	73	15.49	15	5.69				
	8	73	5.10	11	9.09				
	9	73	1.25	15	0.93				
	10	73	2.55	21	2.35				
	11	73	6.80	10	0.96				
	12	73	31.15	9	38.79				
	1	74	21.66	12	12.20				
	2	74	10.76	12	7.82	23	15.12		
	3	74	5.27	4	5.15				
	4	74	14.70	5	3.88	28	2.41		
3906A2	5	73	5.04	5	6.74				
	6	73	18.80	9	6.74				
	7	73	13.59	15	7.48				
	8	73	4.19	11	10.65				
	9	73	1.19	15	1.33				
	10	73	2.27	21	1.67				
	11	73	13.31	10	1.47				
	12	73	13.34	9	8.33				
	1	74	18.66	12	7.02				
	2	74	9.43	12	6.51	23	12.91		
	3	74	7.52	9	4.13				
	4	74	14.14	5	51.82	28	2.78		

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3906 DEER CREEK RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
390681	5	73	0.48	5	0.05				
	6	73	0.14	9	0.13				
	7	73	0.62	15	0.06				
	8	73	0.28	11	0.71				
	9	73	0.01	15	0.03				
	10	73	0.13	21	0.04				
	11	73	0.37	10	0.03				
	12	73	0.68	9	0.42				
	1	74	0.48	12	0.51				
	2	74	0.37	12	0.45	23	0.15		
	3	74	0.20	9	0.34				
	4	74	1.10	5	4.59	28	0.18		
3906C1	5	73	0.25	5	0.03				
	6	73	0.07	9	0.07				
	7	73	0.31	15	0.03				
	8	73	0.14	11	0.37				
	9	73	0.01	15	0.02				
	10	73	0.06	21	0.02				
	11	73	0.18	10	0.02				
	12	73	0.45	9	0.22				
	1	74	0.24	12	0.27				
	2	74	0.19	12	0.23	23	0.08		
	3	74	0.10	9	0.17				
	4	74	0.57	5	2.35	28	0.09		
3906ZZ	5	73	0.79						
	6	73	0.25						
	7	73	1.05						
	8	73	0.51						
	9	73	0.02						
	10	73	0.23						
	11	73	0.65						
	12	73	1.59						
	1	74	0.82						
	2	74	0.65						
	3	74	0.31						
	4	74	1.81						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 73/01/21

340601
39 37 20.0 083 13 02.0
DEER CREEK RESERVOIR
39047 OHIO

11EPALES
3

2111202
0037 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/28	13 25	0000	13.9		18	500	8.20	194	0.080	0.900	4.000	0.037
	13 25	0006	13.9	9.6		500	8.30	194	0.070	0.600	4.000	0.039
	13 25	0015	13.9	9.2		500	8.30	194	0.080	0.600	4.000	0.037
	13 25	0024	13.8	9.1		500	8.30	193	0.070	0.600	4.000	0.036
	13 25	0033	13.8	9.2		490	8.30	192	0.070	0.500	4.000	0.036
73/08/01	17 30	0000	26.9	9.5	48	463	8.70	174	0.090	0.700	2.420	0.007
	17 30	0005	26.5			463						
	17 30	0010	26.0			464						
	17 30	0015	25.6	5.7		466	7.80	175	0.100	0.500	2.500	0.010
	17 30	0020	24.8	1.7		510	7.80	201	0.100	0.400	2.880	0.016
	17 30	0025	24.7			520						
	17 30	0030	24.4	1.1		520	7.90	235	0.200	0.700	2.640	0.016
73/10/10	17 25	0000	20.3	4.6	37	426	8.10	191	0.080	1.300	1.010	0.030
	17 25	0015	20.0	3.4		444	7.90	194	0.140	0.700	1.040	0.037
	17 25	0025	19.5	2.2		470	7.70	212	0.240	0.900	1.100	0.032
	17 25	0034	18.8	1.8		488	7.60	226	0.310	1.200	1.150	0.037

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/28	13 25	0000	0.104	14.4
	13 25	0006	0.094	
	13 25	0015	0.101	
	13 25	0024	0.102	
	13 25	0033	0.104	
73/08/01	17 30	0000	0.043	4.9
	17 30	0015	0.035	
	17 30	0020	0.055	
	17 30	0030	0.103	
73/10/10	17 25	0000	0.059	4.7
	17 25	0015	0.067	
	17 25	0025	0.098	
	17 25	0034	0.103	

STORET RETRIEVAL DATE 75/01/27

3760502
39 37 00.0 083 14 40.0
DEER CREEK RESERVOIR
39147 OHIO

11CPALES
3

2111202
0018 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CONDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/24	14 00	0000	13.1		16	530	8.10	204	0.080	0.800	4.300	0.040
	14 00	0006	13.1	9.3		530	8.30	203	0.070	0.600	4.000	0.040
	14 00	0014	13.0	9.5		530	8.30	203	0.080	0.600	4.000	0.042
73/08/01	18 00	0000	26.3	10.2	36	482	8.80	188	0.070	0.700	2.900	0.007
	18 00	0005	26.4			480						
	18 00	0011	25.8	7.9		479	8.00	184	0.050	0.500	2.960	0.008
73/10/16	17 50	0000	21.0	9.0	48	426	8.40	195	0.060	0.900	0.960	0.019
	17 50	0012	20.4	8.6		432	8.10	194	0.080	0.800	0.890	0.017

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/24	14 00	0000	0.114	14.2
	14 00	0006	0.123	
	14 00	0014	0.110	
73/08/01	18 00	0000	0.030	4.6
	18 00	0011	0.042	
73/10/16	17 50	0000	0.047	12.4
	17 50	0012	0.053	

STORET RETRIEVAL DATE 75/01/27

340003
39 37 33.0 083 15 33.0
DEER CREEK RESERVOIR
39147 OHIO

11EPALES
3

21112C2
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH OF SAMPLE FEET	TEMP WATER DEG C	OXYGEN DISSOLVED MG/L	SPECIFIC CONDUCTANCE FIELD MICROMHO	PH FIELD SU	ALKALINITY TOTAL CACO3 MG/L	NITROGEN AMMONIA TOTAL MG/L	NITROGEN NO2&NO3 N-TOTAL MG/L	PHOSPHORUS ORTHO MG/L P
75/04/24	14 25 0000		11.1		440	7.90	184	0.130	1.100	0.058
	14 25 0034		11.1	11.0	440	7.90	185	0.130	1.100	0.055
75/10/13	14 10 0000		22.7	11.8	38	483	201	0.060	1.100	0.780

DATE FROM TO	TIME OF DAY	DEPTH FEET	NITROGEN AMMONIA-TOT MG/L N	32217 CHLOROPHYL A UG/L
75/04/24	14 25 0000		.035	11.1
	14 25 0034		.020	
75/10/13	14 10 0000		.034	3.0

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APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/02/03

3906A1
39 37 14.0 083 12 46.0
DEER CREEK
39005 7.5 CLARKSBURG
07/DEER CREEK RESERVOIR
2NDRY RD BRDG BELO DAM
11EPALES 21111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 00		3.600	0.980	0.030	0.034	0.090
73/06/09	11 00		2.500	1.680	0.160	0.015	0.065
73/07/15	12 50		2.600	1.890	0.260	0.023	0.080
73/08/11	18 20		1.920	1.470	0.200	0.005K	0.075
73/09/15	13 30		0.850	0.910	0.270	0.007	0.055
73/10/21	13 50		0.910	1.400	0.092	0.016	0.230
73/11/10	14 00		0.920	0.650	0.036	0.016	0.055
73/12/04			2.900	0.500	0.072	0.104	0.175
74/01/12	13 37		3.360	0.500	0.060	0.044	0.080
74/02/10			3.100	0.800	0.090	0.055	0.130
74/02/23	14 00		2.400	1.400	0.015	0.020	0.105
74/03/09	13 30		2.400	0.800	0.010	0.020	0.125
74/04/05	13 40		3.360	0.900	0.060	0.030	0.055
74/04/24	13 30		3.200	0.700	0.035	0.030	0.090

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3906A2
39 39 35.0 083 15 46.0
DEER CREEK
39 7.5 MT STERLING
1/DEER CREEK RESERVOIR
COOK-YANKEETOWN RD BRDG E OF YANKEETON
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 30		3.400	1.010	0.027	0.030	0.070
73/06/09	11 20		4.300	1.300	0.046	0.052	0.130
73/07/15	13 10		2.900	1.640	0.046	0.052	0.165
73/08/11	18 50		1.800	1.760	0.176	0.088	0.270
73/09/15	13 45		1.200	1.150	0.039	0.105	0.180
73/10/21	14 10		0.840	1.100	0.032	0.088	0.290
73/11/10	14 15		1.260	0.400	0.020	0.108	0.135
73/12/09			3.200	0.500	0.032	0.060	0.115
74/01/12	14 00		3.100	0.800	0.040	0.048	0.070
74/02/12			3.360	0.500	0.020	0.040	0.070
74/02/23	14 30		2.000	0.900	0.010	0.025	0.105
74/03/09	13 50		2.100	0.800	0.005K	0.025	0.135
74/04/05	14 00		1.760	0.700	0.020	0.020	0.050
74/04/28	14 00		1.800	0.700	0.015	0.010	0.090

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

390681
39 39 20.0 083 16 16.0
DUFFS FORK
39 7.5 MT STERLING
T/DEER CREEK RESERVOIR
ST HWY 277 BRDG 4.2 MI S OF MT STERLING
11EMALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09	40	4.700	0.400	0.015	0.028	0.050
73/06/09	11	30	4.800	1.680	0.052	0.037	0.080
73/07/15	13	24	5.400	2.940	0.210	0.072	0.140
73/09/15	13	55	0.260	0.920	0.082	0.011	0.030
73/10/21	14	15	0.550	1.050	0.100	0.013	0.175
73/11/10	14	20	0.940	0.600	0.024	0.012	0.025
73/12/04			3.200	0.400	0.052	0.028	0.045
74/01/12	14	15	3.700	0.500	0.036	0.024	0.025
74/02/10			3.600	0.400	0.045	0.025	0.050
74/02/23	14	45	1.900	0.800	0.005	0.010	0.045
74/03/09	14	00	2.100	0.600	0.005K	0.015	0.065
74/04/05	14	10	1.520	0.600	0.030	0.005	0.005
74/04/28	14	15	1.510	0.800	0.015	0.005	0.065

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3906C1
39 39 00.0 083 11 47.0
CLARKS RUN
39 7.5 FIVE POINTS
TYGER CREEK RESERVOIR
DAWSON-YANKEETOWN RD BRDG SE OF YANKEETO
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 15		4.300	0.820	0.028	0.024	0.040
73/06/04	11 15		4.400	1.150	0.044	0.040	0.065
73/07/15	13 00		3.200	1.600	0.082	0.054	0.097
73/08/11	14 40		2.300	1.000	0.083	0.069	0.155
73/09/15	13 35		0.610	0.480	0.046	0.061	0.095
73/10/21	14 00		1.300	0.450	0.044	0.042	0.195
73/11/10	14 10		1.920	0.450	0.006	0.060	0.105
73/12/04			2.760	0.400	0.024	0.028	0.080
74/01/12	13 57		3.300	1.200	0.056	0.028	0.060
74/02/10			3.400	0.500	0.020	0.020	0.040
74/02/23	14 15		2.300	0.400	0.005K	0.025	0.045
74/03/04	13 40		2.500	0.350	0.005K	0.025	0.060
74/04/05	13 50		1.700	0.600	0.030	0.045	0.085
74/04/28	13 40		1.700	0.500	0.025	0.045	0.115

K VALUE KNOWN TO BE
LESS THAN INDICATED

/3

STORET RETRIEVAL DATE 75/02/03

3906AA AS3906AA P001536
39 42 53.0 083 15 41.0
VILLAGE MOUNT STERLING
39005 7.5 MOUNT STERLI
T/DEER CREEK RESERVOIR
DEER CREEK
TIEPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/08/13	08 00								
CP(T)- 73/08/13	16 00		5.800	9.200	0.130	5.400	15.700	0.340	0.230
73/09/17	00 00								
CP(T)- 73/09/17	08 00		5.300	1.300	0.220	5.100	10.800	0.111	0.180
73/10/15	08 00								
CP(T)- 73/10/15	16 00		18.800	0.500K	0.047	5.000	12.500	0.160	0.150
73/11/19	08 00								
CP(T)- 73/11/19	16 00		7.700	4.400	0.094	10.600	13.000	0.136	0.135
73/12/10	08 00								
CP(T)- 73/12/10	16 00		10.900	1.300	0.030	6.200	8.300	0.203	0.180
74/01/11	08 00								
CP(T)- 74/01/11	16 00		7.400	0.940	0.058	3.100	4.300	0.250	0.260
74/02/15	08 00								
CP(T)- 74/02/15	16 00		12.000	1.100	0.200	5.700	6.500	0.290	0.320
74/03/15	08 00								
CP(T)- 74/03/15	16 00		6.100	3.100	0.400	7.500	8.300	0.175	0.210
74/05/17	08 00								
CP(T)- 74/05/17	16 00		3.700	8.300	0.012	9.600	11.000	0.175	0.160
74/06/21	08 00								
CP(T)- 74/06/21	16 00		2.100	3.100	0.075	7.300	7.800	0.140	0.150
74/07/18	08 00								
CP(T)- 74/07/18	16 00		7.800	1.500	0.050K		10.000	0.140	0.145
74/08/15	08 00								
CP(T)- 74/08/15	16 00		2.900	10.000	0.180	13.500	14.000	0.110	0.105

K VALUE KNOWN TO BE
LESS THAN INDICATED